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NUMERICAL RESULTS OF PT IP-412-AI,
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NUMERICAL RESULTS OF PT IP-412-A1,
B AND C REACTORS EXPORT SYSTEM TEST

INTRODUCTION

The purpose of this document is to present the numerical results of a production test⁽¹⁾ of the last ditch water backup system performed at B and C reactors on December 15, 1961. This document will not contain any conclusions or assessments concerning the adequacy or reliability* of the last ditch water backup system.

The main purpose of the production test was to determine more accurately the capacity of the export system for supplying flow to a dual reactor area under several simulated emergency conditions where BPA power to all areas has been interrupted and the steam supply to one old area has been lost. In addition, the flow capacity of the high tanks to the reactor was tested alone and in parallel with the export system, and the action of the surge suppressors at all areas was recorded when cycling of the surge suppressors was deliberately induced.

SUMMARY

The results of these tests will form a basis for analyzing and studying the export system at Hanford and its capacity as a last ditch water backup system for the old and C reactors. The final export system test was divided into five main sections:

- A. Preliminary valving and pumping arrangements were made and preliminary data obtained in this section.
- B. Data were obtained in parts of the export system with the system arranged in several "normal" conditions (no export flow to the reactor).
- C. Full high tank flow to each reactor was obtained when all process water was shut off. Salient results were:

<u>Reactor</u>	<u>Full high tank flow (not at the critical point⁽³⁾)</u>
B	11,000 GPM
C	16,550 GPM

- D. Pressure transients were obtained after the surge suppressors were

* The word "adequacy" refers to the capacity of the export system, in terms of flow and temperature, to prevent boiling in the reactor(s) (sufficient to keep the bulk outlet temperature < 90 C) in an emergency where BPA power to all reactor areas has been interrupted and the steam supply to one old area has been lost. The word "reliability" refers to the degree of certainty that the export line system will function normally in an emergency and that flow to the reactor(s) will be established and maintained in the expected manner.

deliberately cycled (see Figure 1); and the flow split between the high tanks and export system was obtained when the two sources were supplying water in parallel to both reactors at the same time. Salient data obtained were:

<u>Location</u>	<u>Flow in GPM (water level in high tanks <u>not</u> the same as in section C)</u>
Total to 105-B	13,250
high tank flow	9,390
export flow	3,860
Total to 105-C	17,400
high tank flow	11,270
export flow	6,130
From 182 D export steamer	7,280
From 182 H export steamer	6,110
From 182 F export steamer	5,290
Total to 200 area	8,690

E. Flow to both reactors was supplied by the export system alone as different possible emergency export pumping and valving configurations were arranged. Salient data obtained were:

	Steps						
	1	2	3	4	5	6	7
Valving and pumping summary							
282-E	wide open	wide open	throttled	closed	closed	throttled	wide open
282-W	1/2 open	1/2 open	throttled	closed	closed	throttled	1/2 open
N Area	closed	open	closed	closed	closed	closed	closed
182-D export steam pump	on	on	on	on	off	off	off
182 H	on	on	on	on	on	on	on
182 F	on	on	on	on	on	on	on
Flows obtained in GPM							
To B reactor	5010	4970	5130	5440	4810	4380	4120
To C reactor	5330	5170	6250	6990	5830	5330	4930
From 182-D	7420	7410	6460	5400	0	0	0
From 182-H	6150	6100	5480	4720	5710	6280	6640
From 182-F	5400	5540	4110	2670	5170	5970	6350
Total to 200 Area	8630	8095	4670	800*	350*	2540	3940
Total to N Area		815					

* Leaking past closed valve.

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The accuracy of the figures in the tables above have not been included in the summary in order to convey a simple, uncluttered, and quick picture of the test results. In general, the reactor flows listed above are accurate to around two per cent to seven per cent, the export pump flows are accurate to around two per cent to 20 per cent, and the flows at 200 area may only be accurate to about 200 per cent in certain cases. All accuracy figures are shown in the tables in the discussion below, and a more detailed explanation of the significance and calculation of these numbers is included in sections III and IV of the discussion.

DISCUSSION

I. Test Summary

The following summary briefly describes each section of the test as it was performed. This summary outlines the basic objectives of the test and will provide an overall perspective of the test and the data obtained without the numerous details incorporated in the test procedure.

A. Preliminary Arrangements

This section included specifications for various valving conditions, preliminary process pumping, and monitoring of reactor flows and outlet temperatures during the test.

B. Pre-Test Export Pumping

Flow and pressure data were obtained with the export system arranged in several different "normal" pumping and valving conditions. This was done in order to establish hydraulic parameters for the export system under present "normal" conditions and to provide a base point for evaluating the effects of future changes.

C. Simulated Emergency High Tank Flow

All process water flow to B and C reactors was shut off and high tank flow rates to each reactor were measured. This was done in order to assist in monitoring the current high tank water backup adequacy at these reactors.

D. Surge Suppressor Transients and Combined High Tank and Export System Flow

After high tank flow to the reactors was established, the C reactor export Grove valve was opened suddenly in order to cause the surge suppressors to cycle. The resulting pressure transients (which have important effects on the reliability of the export system) were recorded at each 182 building. After the surge suppressors cycled, the individual high tank and export system flow contributions to each reactor was obtained. These data will assist in determinations of export system water backup adequacy by indicating the time when

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the high tanks would have emptied and adequate reactor cooling water would have had to come from the export system alone.

E. Export System Capacity

The high tank flow to each reactor was shut off and the export system alone supplied water to both reactors, the 200 areas, and N area at the same time under various simulated emergency pumping and valving arrangements. Flow and pressure data were obtained at certain points in the export system and at the reactor for each step in this section. These data will be used in determining export system water backup adequacy under different simulated emergency conditions, and in investigating the need for changes in the export system under these and other emergency conditions.

II. Detailed Test Data

The following section contains a brief description of every step performed in each section of the test and tables of the basic data obtained in these steps.

A. Preliminary Valving Arrangements and Reactor Hydraulic Characteristics

1. The flow balancing valve between the near and far sides was open at each reactor.
2. Last ditch water backup to the filtered water supply and to the HCR and shield cooling systems was valved off at both reactors. However, water to the HCR's was being supplied through the normal process water connections on the risers.
3. All reactor crossheaders were valved to normal. Tube loadings at B reactor were normal; however, there were roughly 50 empty tubes at C reactor. The reactor hydraulic characteristics under the test conditions and at high flow were monitored by obtaining the following data:

	<u>B Reactor</u>	<u>C Reactor</u>
Flow (with Foxboro flow transmitters)	81,600 ± 400 gpm	89,200 ± 900 gpm
TORP (with Heise gauge in control room) at top-of-riser	516 ± 1 psig	343 ± 1 psig
Inlet temperature	7°C	8°C
Outlet temperature	8°C	9°C

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4. Prior to the initiation of high tank flow to the reactors, special pump and valving configurations were arranged at 190-B and C. Flows and pressures were obtained as part of a special flow reduction schedule for the test as outlined below. The data, however, are much less accurate than that listed in item 3 above (no accuracy figures were obtained since these data will probably not be used in any analyses).

	<u>B Reactor</u>	<u>C Reactor</u>
Flow (with flow chart in control room)	26,700 gpm	37,000 gpm
TORP (with Heise gauge in control room) at top-of-riser	61-1/2 psig	71-1/2 psig
Inlet temperature	-- 7°C	-- 8°C
Outlet temperature	-- 9°C	-- 9°C

B. Pre-Test Export Pumping

1. The intake valve at 282-E was opened wide open, the intake valve at 282-W was opened about half way (in terms of flow), and an export water flow of about 1000 gpm was arranged at 100 N. All other users of export water were restricted to less than 25 gpm during the remainder of the test.
2. The export steam pump and three electric export pumps were operated at 182-B, and flow to 100-N was readjusted to about 1000 gpm.* Data were then obtained (see Table 1).
3. The pumping configuration on the export system was then rearranged so the export steam pump in each 182 building was pumping to the export line unthrottled and with no Copes control. One electric export pump was operated at 182-B in addition in order to maintain the export system pressure at 182-B at about the same value as was obtained in step 2 above. Data were then obtained (see Table 1).
4. The export water supply to N area was shut off and data were then obtained (see Table 1).
5. All export pumps at 182-B were shut down and data were then obtained (see Table 1).

* This flow was adjusted with a throttle valve and the setting on this valve was not changed hereafter during the rest of the test. When export water flow to N area was shut off and restarted, a guard valve upstream of the throttle valve was used.

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TABLE 1
DATA SHEET FOR SECTION B

Export status summary: 282-E wide open, 282-W half open, 105-B and C shut off, all other users of export water throttled to 25 gpm.

Measurement	Steps			
	2	3	4	5
182 B pump flows				
Suction pressure in psig	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	--
Discharge pressure in psig				
steamer	228 ± 2	228 $\frac{1}{2} \pm 2$	231 ± 2	--
electric	225 ± 2	--	--	--
electric	227 ± 2	245 $\frac{1}{2} \pm 2$	251 ± 2	--
electric	225 ± 2	226 ± 2	229 ± 2	--
Speed in rpm				
steamer	1840 ± 5	1815 ± 5	1820 ± 5	--
electric	1780 ± 5	--	--	--
electric	1782 ± 5	1780 ± 5	1780 ± 5	--
electric	1785 ± 5	1775 ± 5	1780 ± 5	--
Flow (from pump calibration curves and data above) in gpm				
steamer (condensing)	4560 ± 770 -640	4030 ± 1160 -660	3930 ± 1080 -650	off
electric	3470 ± 1310 -600	off	off	off
electric	3370 ± 1030 -390	0 ± 460 -0	0 ± 0 -0	off
electric	3600 ± 1300 -590	3250 ± 1430 -660	3060 ± 1550 -260	off
182 D steam pump flow (not condensing)				
Suction pressure in psig	--	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$
Discharge pressure in psig	--	221 $\pm 1\frac{1}{2}$	223 $\pm 1\frac{1}{2}$	178 $\pm 1\frac{1}{2}$
Speed in rpm	--	1720 ± 5	1720 ± 5	1650 ± 5
Flow (from pump calibration curves and data above) in gpm	off	1450 ± 820 -1150	1000 ± 970 -1000	4420 ± 310 -300
182 H steam pump flow (condensing)				
Suction pressure in psig	--	$4\frac{1}{2} \pm \frac{1}{4}$	$4\frac{1}{2} \pm \frac{1}{4}$	$4\frac{1}{2} \pm \frac{1}{4}$
Discharge pressure in psig	--	246 ± 2	247 ± 2	209 ± 2
Speed in rpm	--	1825 ± 10	1810 ± 10	1760 ± 10
Flow (from pump calibration curve and data above) in gpm	off	4500 ± 450 -590	4060 ± 530 -700	5630 ± 290 -380

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Table 1 (continued)

Measurements

182 F steam pump flow
(condensing)

Suction pressure in psig

Discharge pressure in psig

Speed in rpm

Flow (from pump calibration
curves and data above)
in gpm

Export header pressures in psig

182 B)

182 D) Corrected to floor

182 H) of 182 building

182 F)

282 E)

) Corrected to E

282 W) of export line

200 & N area flows

N export flow

Orifice - P Hg

Flow in gpm

200 Area in gpm

282-E

282-W

	Steps			
	2	3	4	5
Suction pressure in psig	--	$6\frac{1}{2} \pm \frac{1}{4}$	$6\frac{1}{2} \pm \frac{1}{4}$	$6\frac{1}{2} \pm \frac{1}{4}$
Discharge pressure in psig	--	$240\frac{1}{2} \pm 2$	248 ± 2	$210\frac{1}{2} \pm 2$
Speed in rpm	--	1757 ± 5	1775 ± 5	1741 ± 5
Flow (from pump calibration curves and data above) in gpm	off	1630 ± 670 -1630	2210 ± 590 -1710	4530 ± 240 -340
Export header pressures in psig				
182 B)	$228 \pm \frac{1}{2}$	$228 \pm \frac{1}{2}$	$230 \pm \frac{1}{2}$	$173 \pm \frac{1}{2}$
182 D) Corrected to floor	$206 \pm \frac{1}{2}$	$222\frac{1}{2} \pm 1\frac{1}{2}$	$224\frac{1}{2} \pm 1\frac{1}{2}$	$178\frac{1}{2} \pm 1\frac{1}{2}$
182 H) of 182 building	227 ± 2	247 ± 2	248 ± 2	210 ± 2
182 F)	$225\frac{1}{2} \pm 2$	$245\frac{1}{2} \pm 2$	247 ± 2	$209\frac{1}{2} \pm 2$
282 E)	$22\frac{1}{2} \pm 3$	$24\frac{1}{2} \pm 3$	25 ± 3	16 ± 3
) Corrected to E	-2	-2	-2	-2
282 W) of export line	$62\frac{1}{2} \pm 1$	$71\frac{1}{2} \pm 1$	$72\frac{1}{2} \pm 1$	$39\frac{1}{2} \pm \frac{1}{2}$
200 & N area flows				
N export flow				
Orifice - P Hg	$32\frac{1}{2} \pm \frac{1}{2}$	$30 \pm \frac{1}{2}$	--	--
Flow in gpm	1025 ± 10	985 ± 10	Off	Off
200 Area in gpm				
282-E	13,975	13,875	14,260	14,580
282-W	9320 ± 1500	9250 ± 1500	9500 ± 1500	9720 ± 1500
	4655 ± 1500	4625 ± 1500	4760 ± 1500	4860 ± 1500

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C. Simulated Emergency High Tank Flow

1. The reactor valving was arranged and reactor hydraulic characteristics were monitored as outlined in section A above.
2. At C reactor both high tank Grove valves were open, and at B reactor both sets of high tank strainer gates had been removed thus allowing flow through both sides of the strainer (this has not been done at C reactor).
3. All process water flow to both reactors was shut off or valved off completely, full high tank flow to the reactors was established, and the following data were taken:

	<u>B Reactor</u>	<u>C Reactor</u>
TORP (with W&T gauge) in psig	19.4 $\pm$.05	22.4 $\pm$.05
High tank flow (from TORP and calibration curve) in gpm	11,000 $\pm$ 330	16,550 $\pm$ 410
Near high tank water level below overflow at time of TORP measurement in H ₂ O	40.8 $\pm$ 1	35.7 $\pm$ 6
Far high tank water level below overflow at time of TORP measurement in H ₂ O	45.5 $\pm$ 1	30.6 $\pm$ 1
Avg. reactor bulk inlet temp. in °C.	8.0 $\pm$.5	8.6 $\pm$.5
Avg. reactor bulk outlet temp. in °C.	10.0 $\pm$.5	10.0 $\pm$.5
Near high tank strainer ΔP in psig	2 $\pm$ 1	4-1/2 $\pm$ 2
Far high tank strainer ΔP in psig	4 $\pm$ 1	7 $\pm$ 2

D. Surge Suppressor Transients and Combined High Tank and Export System Flow

1. After full high tank flow to the reactors was established, the C reactor export Grove valve was opened quickly; this action caused all surge suppressors on the export system to cycle, and the pressure transients that were caused were recorded on high speed recorders located at each 182 building. A rough copy of the pressure transients is depicted in Figure 1.
2. After the pressure transients had been recorded and all surge suppressors were closed, the Grove valve at B reactor was opened. Both reactors were then being supplied with water from the high tanks and the export system together. (The pumping and valving configuration on the export system had not been changed from that arranged for step B.5 above). Data were then taken. (See Table 2).

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TABLE 2

DATA SHEET FOR SECTION D

Export status summary: 282-E wide open, 282-W half open, export steam pumps operating at 182-D, H, and H, N area closed, 105 B and C open and supplied with high tank and export water together.

<u>Measurement</u>	<u>Value (average of about 10 sets of data taken at 1 min. intervals)</u>
B Reactor	
TORP (with W&T gauge) in psig	24.6 ± .05
Total flow to reactor (from TORP and calibration curve) in gpm	13,250 ± 310
Near high tank flow (from manometer measurements) in gpm	4,500 ± 100
Far high tank flow (from manometer measurements) in gpm	<u>4,890</u> ± 100
Total high tank flow	9,390
Flow from the export system (total flow to reactor - total flow from high tanks) in gpm	3,860
Water level at midpoint of readings, near, in H ₂ O below full point	173-1/2 ± 1
Water level at midpoint of readings, far, in H ₂ O below full point	191-1/2 ± 1
Reactor bulk inlet temperature in °C	7.6 ± .5
Reactor bulk outlet temperature in °C	11.3 ± .5
Near high tank strainer P in psig	2-1/4 ± 1/2
Far high tank strainer P in psig	2-1/2 ± 1/2
C Reactor	
TORP (with W&T gauge) in psig	24.05 ± .05
Total flow to reactor (from TORP and calibration curve) in gpm	17,400 ± 420
Near high tank flow (from manometer measurements) in gpm	6,240 ± 640
Far high tank flow (from manometer measurements) in gpm	<u>5,030</u> ± 100
Total high tank flow	11,270

Table 2 (cont.)

Measurement

Value (average of
about 10 sets of
data taken at 1 min.
intervals)

C Reactor (cont.)

Flow from the export system (total flow to reactor - total flow from high tanks) in gpm	6,130
Water level at midpoint of readings, near, in H ₂ O below full point	197 ± 6
Water level at midpoint of readings, far, in H ₂ O below full point	146 ± 1
Reactor bulk inlet temperature in °C	8.6 ± .5
Reactor bulk outlet temperature in °C	10.1 ± .5
Near high tank strainer ΔP in psig	4 ± 1
Far high tank strainer ΔP in psig	3-1/2 ± 1

Export Steam Pump Flows

182-D (not condensing)

Suction pressure in psig	4-1/2 ± 1/2
Discharge pressure in psig	157 ± 1-1/2
Speed in RPM	1,811 ± 5
Flow (from pump calibration curves and data above) in gpm	7,280 +110 -130

182-H (condensing)

Suction pressure in psig	4-1/2 ± 1/4
Discharge pressure in psig	190 ± 2
Speed in RPM	1,730 ± 10
Flow (from pump calibration curves and data above) in gpm	6,110 ± 290

182-F (condensing)

Suction pressure in psig	6-1/2 ± 1/4
Discharge pressure in psig	192-1/2 ± 2
Speed in RPM	1,730 ± 5
Flow (from pump calibration curves and data above) in gpm	5,290 + 240 - 250

Export System Pressures

105-B (corrected to E of export piping)

Upstream of orifice in psig	90-1/2 ± 1
Downstream of orifice in psig	45 ± 1
Downstream of strainer in psig	41-1/2 ± 1

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Table 2 (cont.)

Value (average of
about 10 sets of
data taken at 1 min.
intervals)

Measurement

Export System Pressures (cont.)

105-C (corrected to $\bar{L}$ of export piping)	
Upstream of orifice in psig	105 ± 2
Downstream of orifice in psig	62 ± 2
Downstream of strainer in psig	62 ± 2
182-B (corrected to 182 building floor) in psig	142 $\pm 1/2$
182-D (corrected to 182 building floor) in psig	155-1/2 $\pm 1/2$
182-H (corrected to 182 building floor) in psig	190 ± 2
182-F (corrected to 182 building floor) in psig	189-1/2 ± 2
282-E (corrected to $\bar{L}$ of export piping) in psig	9-1/2 ± 1
282-W (corrected to $\bar{L}$ of export piping) in psig	20-1/2 $\pm 1/2$

200 and N Area Flows

N export flow	--
Orifice ΔP in Hg	off
Flow in gpm	
200 Area in GPM	8,690
282-E	5,800 ± 1000
282-W	2,890 ± 1000

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1. All high tank flow to both reactors was shut off completely so all water being supplied to the reactors was coming from the export system. The pumping and valving configuration on the export system had not been changed from that arranged for step B.5 above. This arrangement consisted of the export steam pumps operating unthrottled at 182-D, F, and H; 282-E opened wide open; 282-W opened half way (in terms of flow); and N area shut off. Data were then taken (see Table 3).
2. Flow to N area was then re-established with the throttle valve in the same position that was established in step B.2 above. Data were then taken (see Table 3).
3. Flow to N area was shut off, and flow to 282-E and 282-W was throttled by closing the large cone valves and opening the eight-inch by-pass lines as nearly as possible to the positions where minimum emergency flow rates* were being obtained. Data were then taken (see Table 3).
4. All flow to 282-E and 282-W was shut off and data were then taken (see Table 3).
5. The export steam pump at 182-D was shut down and data were then taken (see Table 3).
6. The by-pass valves at 282-E and 282-W were returned as closely as possible to the positions obtained in step 3 above. Data were then taken (see Table 3).
7. The large cone valves at 282-E and 282-W were reopened as closely as possible to the original position arranged in step B.1 above, and the by-pass valves were shut off. Data were then taken (see Table 3).

* 2700 gpm at 282-E and 900 gpm at 282-W.

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Valving and pumping summary

Measurements

TORP (with W&T gauge) in psig

[illegible]

TORP (with W&T gauge) in psig

[illegible]

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Table 3 (continued)

	1	2	3	4	5	6	7
Export Steam Pump Flows							
182-D (not condensing)							
Suction pressure	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$	$4\frac{1}{2} \pm \frac{1}{2}$
in psig							
Discharge pressure	153 ± 1	151 ± 1	185 ± 1	212 ± 1			
in psig							
Speed in rpm	1820 ± 5	1815 ± 5	1820 ± 5	1840 ± 5			
Flow (from pump	7420 ± 90	7410 ± 100	6460 ± 170	5400 ± 230			
calibration curves	-100	-90	-160	-230	off	off	off
and data above)							
in gpm							
182-H (condensing)							
Suction pressure	$4\frac{1}{2} \pm \frac{1}{4}$	$4 \pm \frac{1}{4}$	$4 \pm \frac{1}{4}$	$4 \pm \frac{1}{4}$	$4 \pm \frac{1}{4}$	$4 \pm \frac{1}{4}$	$4 \pm \frac{1}{4}$
in psig							
Discharge pressure	189 ± 2	187 ± 2	217 ± 2	238 ± 2	195 ± 2	180 ± 2	169 ± 2
in psig							
Speed in rpm	1730 ± 10	1720 ± 10	1780 ± 10	1810 ± 10	1720 ± 10	1710 ± 10	1700 ± 10
Flow (from pump	6150 ± 280	6100 ± 270	5480 ± 340	4720 ± 440	5710 ± 310	6280 ± 270	6640 ± 24
calibration curves	-290	-300	-380	-490	-350	-280	-28
and data above)							
in gpm							
182-F							
Suction pressure	$6 \pm \frac{1}{4}$	$6 \pm \frac{1}{4}$	$6 \pm \frac{1}{4}$	$6 \pm \frac{1}{4}$	$6 \pm \frac{1}{4}$	$6 \pm \frac{1}{4}$	$6 \pm \frac{1}{4}$
in psig							
Discharge pressure	190 ± 2	188 ± 2	219 ± 2	239 ± 2	198 ± 2	183 ± 2	173 ± 2
in psig							
Speed in rpm	1730 ± 5	1735 ± 5	1750 ± 5	1760 ± 5	1740 ± 5	1750 ± 5	1750 ± 5
Flow (from pump	5400 ± 230	5540 ± 220	4110 ± 290	2670 ± 500	5170 ± 230	5970 ± 200	6350 ± 13
calibration curves	-270	-240	-350	-530	-270	-220	-13
and data above)							
in gpm							
Export System Pressures							
105-B (corrected to							
2 of export piping							
Upstream of orifice	$80\frac{1}{2} \pm 1$	$79\frac{1}{2} \pm 1$	102 ± 1	$116\frac{1}{2} \pm 1$	91 ± 1	80 ± 1	72 ± 1
in psig							
Downstream of	$29\frac{1}{2} \pm 1$	$29\frac{1}{2} \pm 1$	$32\frac{1}{2} \pm 1$	$34\frac{1}{2} \pm 1$	$31\frac{1}{2} \pm 1$	30 ± 1	29 ± 1
orifice in psig							
Downstream of	25 ± 1	25 ± 1	$25\frac{1}{2} \pm 1$	26 ± 1	25 ± 1	$24\frac{1}{2} \pm 1$	24 ± 1
strainer in psig							

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Table 3 (continued)

	1	2	3	4	5	6	7
105-C (corrected to E of export piping)							
Upstream of orifice in psig	96 ± 2	95 ± 2	124 ± 2	144 ± 2	110 ± 2	96 ± 2	86 ± 2
Downstream of orifice in psig	38 ± 2	37 ± 2	42 ± 2	46 ± 2	40 ± 2	38 ± 2	37 ± 2
Downstream of orifice in psig	38 ± 2	37 ± 2	42 ± 2	46 ± 2	40 ± 2	38 ± 2	37 ± 2
182-B corrected to 182 building floor)	138 $\pm \frac{1}{2}$	136 $\pm \frac{1}{2}$	175 $\pm \frac{1}{2}$	203 $\pm \frac{1}{2}$	156 $\pm \frac{1}{2}$	137 $\pm \frac{1}{2}$	123 $\pm \frac{1}{2}$
in psig							
182-D (corrected to 182 building floor)	153 $\frac{1}{2} \pm 1$	149 $\frac{1}{2} \pm 1$	187 $\frac{1}{2} \pm 1$	212 $\frac{1}{2} \pm 1$	162 $\frac{1}{2} \pm 1$	142 $\frac{1}{2} \pm 1$	130 $\frac{1}{2} \pm 1$
in psig							
182-E (corrected to 182 building floor)	189 ± 2	187 ± 2	217 ± 2	239 ± 2	196 ± 2	180 ± 2	169 ± 2
in psig							
182-F (corrected to 182 building floor)	187 $\frac{1}{2} \pm 2$	185 $\frac{1}{2} \pm 2$	216 $\frac{1}{2} \pm 2$	236 $\frac{1}{2} \pm 2$	195 $\frac{1}{2} \pm 2$	180 $\frac{1}{2} \pm 2$	169 $\frac{1}{2} \pm 2$
in psig							
282-E (corrected to E of export piping)	6 ± 1	5 $\frac{1}{2} \pm 1$	56 $\frac{1}{2} \pm 1$	90 $\frac{1}{2} \pm 1$	43 ± 1	20 ± 1	4 $\frac{1}{2} \pm 1$
in psig							
282-W (corrected to E of export piping)	18 $\pm \frac{1}{2}$	16 $\frac{1}{2} \pm \frac{1}{2}$	62 $\frac{1}{2} \pm \frac{1}{2}$	91 $\frac{1}{2} \pm \frac{1}{2}$	43 $\frac{1}{2} \pm \frac{1}{2}$	22 $\frac{1}{2} \pm \frac{1}{2}$	8 $\frac{1}{2} \pm \frac{1}{2}$
in psig							

200 & N Area Flows

N export flow
Orifice P in Hg
Flow in gpm

--	19 $\frac{1}{4} \pm \frac{1}{2}$	--	--	--	--	--
--	815 ± 10	--	--	--	--	--

200 Area in gpm	8630*	8095*	4670*	800+1500**	350+600**	2540*	3940*
282-E	5750 ± 1000	5400 ± 1000	3220 $\square$	-500	-200	2140 $\square$	2630 ± 500
282-W	2880 ± 1000	2695 ± 1000	1450+1000	800+1500	350+600	400+300	1310 ± 500
			-300*	-500**	-200**	-100	

* Calculated by subtracting flow to 105-B, 105-C, and N area from pump flows at 182-D, F, & H.

$\neq$ 282-E flow = 2/3 of total 200 area flow and 282-W flow = 1/3 of total 200 area flow (estimated based on valve position).

★ 282-W flow = flow monitored by orifice plus estimated leakage through cone valve.

□ 282-E flow = flow to 200 area minus flow to 282-W.

** Estimated leakage through cone valve at 282-W.

★★ All flow shut off at 282-E (but some leakage that was not noticed may have occurred).

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III. Calculations

A. Export Steam Pumps

1. Prior to the export system test, a series of export steam pump calibration tests were performed at 182-D, F, and F. These calibration tests were performed by isolating the 182 building, installing a flow measuring orifice in the import line, and pumping from the reservoir through the import line back into the reservoir (this test is described briefly in reference 1). From the data obtained during these tests, the pump calibration curves shown in Figures 2, 3, 4, and 5 were obtained. Curves at different pump speeds were calculated by using the normal pump affinity laws shown below:

$$\frac{n_1}{n_2} = \frac{F_1}{F_2} = \frac{(TDH_1)^{1/2}}{(TDH_2)^{1/2}}$$

where n = pump speed in rpm

F = pump flow in gpm

TDH = pump total dynamic head in ft.

2. The export steam pump calibration test at 182-B was unsuccessful and has not been rerun as yet. Since no experimental curve for the export steam pump at 182-B was available, a curve was assumed based on the dead headed pressure of the pump and the shape of the other 182 building pump curves.
3. During the steps in the export system test, all pump speeds and pressures were measured. These data were then used together with the pump calibration curves to obtain the corresponding pump flows.

B. Reactor Flows

1. Prior to the export system test, a series of reactor calibration tests were performed at all reactors including B and C^(2,3). The results of these tests included curves of TORP vs. flow which described the hydraulic characteristics of the reactors at that time. For this test, new TORP vs. flow curves were drawn for B and C reactors (see Figures 6 and 7) which paralleled the curves shown in references 2 and 3. The position of the new curves were defined by the high flow data that was taken just after the export system test. These new curves describe the hydraulic characteristics of each reactor at the time of the export system test.
2. During the steps in the export system test, reactor TORP's were measured and recorded. These data were then used together with the new reactor calibration curves to obtain the corresponding reactor flows.

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C. High Tank Flows

1. During section C of the export system test, full high tank flow to each reactor was measured by obtaining the resultant TORP and converting this to reactor flow with the reactor calibration curve.
2. During section D of the export system test when the high tank and export systems were supplying water to each reactor together, the high tank flow contribution was monitored by measuring the drop in water level in the high tanks with a mercury manometer over measured time intervals. The total flow to each reactor was monitored by measuring TORP (as described above), and the flow contributed by the export system was obtained by subtracting the high tank flow contribution from the total flow to the reactor.

D. Flows at 200 Areas and N Area

1. During section B of the export system test, all water being supplied by the export pumps was going to the 200 areas and, during some steps, to N area. Flow to N area was monitored with a flow measuring orifice installed in a temporary line through which all water supplied to N area from the export system was diverted and controlled. Since the large intake cone valve was opened wide at 282-E and opened about halfway (in terms of flow) at 282-W, the flow at 282-E was assumed to be about two-thirds of the total flow to the 200 areas (total flow to the 200 areas equaled the flow from the 182 building export pumps minus the flow to N area, if any) and the flow at 282-W was assumed to be about one-third of the total flow to the 200 areas.
2. During steps 1, 2, and 7 in section E of the export system test flows to 200 and N areas were measured as described in 1 above except that the total flow to 200 areas was obtained by subtracting the flow to N area and to the reactors from the total flow being delivered by the 182 building export steam pumps.
3. During steps 3 and 6 in section E of the export system test, the large cone valves were closed and flow to 282-E and 282-W was diverted through by-pass lines in which flow measuring orifices had been installed. However, at 282-E the manometer used to measure the ΔP across the orifice malfunctioned, and at 282-W water was leaking past the closed cone valve. Flows at 282-E were subsequently calculated by subtracting the estimated flow to 282-W from the total flow to the 200 areas, and the total flow to the 200 areas was calculated as described in 2 above. The flows at 282-W were estimated by adding together the flow measured at the orifice, and the flow estimated to be leaking past the cone valve and over the intake weir. Calculations to

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estimate the flow of water discharging over the intake weir were based on observations made of water discharging over the weir during and after the test, the relative pressures upstream of the cone valve, and the King weir formula⁽⁴⁾:

$$Q = 3.34 L H^{1.47} \left[1 + .056 \left(\frac{LH}{A} \right)^2 \right]$$

where:

Q = flow in ft.³/sec.
L = width of weir in ft.
H = height of water going over weir in ft.
A = area of approach to weir in ft.

4. During steps 4 and 5 in section E of the export system test the flow to the 200 areas was shut off. However, water was leaking past the cone valve at 282-W and estimates of the quantity of water leaking past the valve were made as described in 3 above.

D. Export System Pressures

Pressure at various points in the export system were measured directly with Heise gauges and corrected to convenient elevations as noted in the tables. At 282-E, the pressure tap on the export line was located in a section of the line where the diameter of the line was reduced from a 24-inch O.D. to a 12-inch O.D. Standard corrections were made to the measured static pressures in order to compensate for the change in water velocity from the 24-inch O.D. section to the 12-inch O.D. section.

IV. Accuracy

1. The accuracy of all data taken directly is noted by the $\pm$ figures in the tables; and indicates, in the best judgment of the data taker and the overall test coordinator, that the actual reading probably lies somewhere within that range. These figures define the accuracy of the readings as limited by oscillations of the needle, the spacing of the scale on the gauge, any unexplained odd behavior of the gauge, and the ability of the data taker to read the gauge within those limitations. This applies to all pressure readings, pump speed readings, orifice ΔP readings, high tank manometer readings, and temperature readings. Special cases are described below.
2. The accuracy figures attached to the pump flows listed in the tables were obtained by adding maximum errors in pressures and speeds together and determining the largest possible resulting variations in flow from the calibration curves. Also included in the accuracy calculations is an allowance for error in the experimental determination of the original pump calibration curve (this allowance is much larger for the 182-B export pumps where no experimental curves have been obtained).

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3. The accuracy of the listed reactor flows was calculated by obtaining maximum possible flow variations resulting from the maximum possible variations in the recorded top-of-riser pressures and by including an allowance for error in the determination of the original reactor calibration curves.
4. Manometer readings on the near high tank were judged to be less accurate because the manometer did not return to its original full mark; a special error allowance was subsequently made for that data.
5. In cases where flow rates were obtained by adding or subtracting other flow rates derived from experimental data, no accuracy figures were attached. This was done since the flows derived by addition or subtraction of other flows were not based directly on experimental data (e.g., total high tank flows and export flows to the reactors in test section D; and the total export flow to the 200 areas in steps 1, 2, 3, 6, and 7 of test section E).
6. In steps 1, 2, and 7 of section E in the export system test, accuracy figures attached to flows at 282-E and 282-W are a rough arbitrary estimate of the accuracy of the flow split between 282-E and 282-W based on the valve positions.
7. In steps 3 and 6 of section E in the export system test, the flows at 282-W were calculated based on orifice and weir measurements, so accuracy figures were derived based on the error in the data and the resulting error in the flows. However, total flows to the 200 area and flows to 282-E were obtained by difference so no accuracy figures are listed (see item 5 above).
8. In steps 4 and 5 of section E in the export system test, the flows at 282-W (and therefore the total to the 200 areas) were calculated based on weir observations and estimated accuracy figures are therefore included. These two steps also provided a means of checking the methods used for obtaining flows throughout the export system since the flow being monitored at the 182 buildings should have equaled the flows being obtained at B and C reactors and the 200 areas (i.e., all flows throughout the export system were obtained directly from observed data during these two steps, so the flow input should have equaled the flow going out). The discrepancy amounted to about 3-1/2 per cent in step 4 and about one per cent in step 5.

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SURGE SUPPRESSORS C

Figure 1

CYCLING TRANSIENTS

NOTE: THE TIME WHEN THE SURGE SUPPRESSORS OPENED WAS NOT MARKED ON THE RECORDER CHARTS. TIMING MARKED HERE WAS DEDUCED FROM OBSERVATIONS MADE DURING THE TEST AND THE SHAPE OF THE PRESSURE RECORDINGS. TIMES REQUIRED FOR SURGE SUPPRESSORS TO CLOSE WAS MEASURED WITH WATCHES.

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182 F BLDG.

182 H BLDG.

182 D BLDG.

182 B BLDG.

180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360
 3 MIN. 4 MIN. 5 MIN. 6 MIN.
 SECONDS

EXPORT PUMP CHARACTERISTICS **ESTIMATED BASED ON D.F.H. PUMP TESTS & B DEADWEIGHT DATA**

Figure 2

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D EXPORT STEAM PUMP CHARACTERISTICS

Figure 3

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F EXPORT STEAM PUMP CHARACTERISTICS

Figure 5

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C CHARACTERISTICS

SED ON RECENT
A-DRAWN
LD CURVE

H (1) CURVE FROM REF. (3)
(DATA WITH 0)

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RESSURE) IN PSIG

DATE

FILMED

10/11/94

END

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